

Visualization Criticism – The Missing Link Between Information Visualization and Art

Robert Kosara
The University of North Carolina at Charlotte
rkosara@uncc.edu

Abstract

Classifications of visualization are often based on technical criteria, and leave out artistic ways of visualizing information. Understanding the differences between information visualization and other forms of visual communication provides important insights into the way the field works, though, and also shows the path to new approaches.

We propose a classification of several types of information visualization based on aesthetic criteria. The notions of artistic and pragmatic visualization are introduced, and their properties discussed. Finally, the idea of visualization criticism is proposed, and its rules are laid out. Visualization criticism bridges the gap between design, art, and technical/pragmatic information visualization. It guides the view away from implementation details and single mouse clicks to the meaning of a visualization.

1 Introduction

Two cultures exist in visualization: very technical, analysis-oriented work on the one, and artistic pieces on the other hand. The type that shall be called *pragmatic visualization* below is mostly practiced by people in computer science with no background in art or design. A student once put it aptly: *Computer graphics is mostly computers, but little graphics*. At the same time, artists and designers often work on visualizations without much knowledge of the technical work being done in computer science.

Information visualization (InfoVis) is such an inherently interdisciplinary field that it requires a much more integrated approach. Since this is not the case right now, it needs to be created from the two extremes that exist. In analogy to a concept in the natural sciences [2], this could be called *the third culture of visualization*. Such a third culture would consist not only of people working in the respective fields, but a strong interchange of ideas between them.

The techniques developed in both scientific and information visualization are certainly useful, but an clear picture

of what constitutes visualization and a foundational theory are still missing. Even for the practical work that is being done, there is very little discussion of approaches, with many techniques being developed ad hoc or as incremental improvements of previous work.

Since this is not a technical problem, a purely technical approach cannot solve it. We therefore propose a third way of doing information visualization that not only takes ideas from both artistic and pragmatic visualization, but unifies them through the common concepts of critical thinking and criticism. Visualization criticism can be applied to both artistic and pragmatic visualization, and will help to develop the tools to build a bridge between them.

2 Related Work

Several models of information visualization have been proposed. Most of them are very technical and describe either the process of the visualization [4] or the data [17]. An interesting recent paper [20] uses two criteria to differentiate between information and scientific information: discrete vs. continuous data, and whether the spatial layout of the visualization is given or chosen.

Sack [16] compares InfoVis to conceptual art, and argues for the adoption of an aesthetics of administration: rather than looking at the surface, evaluate the type of governance a particular visualization enables. Sack's article will be mentioned again below.

Goodman's theories on art and language [7, 14] provide an interesting approach to a classification of representation and the visual. His ideas about visual languages resonate well with information visualization, even though most visualizations do not fulfill his requirements for a language. Studying them is still useful to learn more about visualization and its relations to other fields. Cox [5] suggests a generalized view on visualization metaphors than it is usually understood, thus linking the elusive (and often misunderstood) concept of the metaphor to concrete technical implementations of visualization systems.

3 What is Information Visualization?

A good part of the confusion about visualization comes from the fact that there is no clear or generally accepted definition of visualization. Such a definition would clearly vary between fields, but at least within one field (like computer science, design, illustration, etc.), it needs to be consistent. Also, by understanding the differences between definitions in different fields, we can identify elements that help in building the bridge between them. These are not just the similarities though, but also the differences that require investigation.

Examples for visualization are: architectural visualization, terrain visualization, 3D medical/volume visualization, 2D or 3D flow visualization, flow topology visualization, presentation graphics, abstract data visualization, information dashboards, music visualization, photomontage or collage, traffic signs, traffic signals, sign language, icons, visualizing oneself in a different job/situation, visualization of concepts, drawing fractals, etc.

These are clearly very different types of visual communication, and many of them are not generally considered visualization; others are, but only by specific groups. Why is that? And how can we differentiate between them in a way that is not ad hoc?

We consider the following criteria to be a minimal set of requirements for any visualization. The remainder of this discussion will concentrate on information visualization, but these criteria apply equally to scientific visualization.

It is based on (non-visual) data. The data to be visualized must come from outside the program, and the program must be able (at least in principle) to work on different data sets. Also, visualization is not image processing or photography; if the source data is an image and is used as an image in the result, it is not being visualized.

It produces an image. Clearly, each visualization has the goal of producing one or more images from the data, and the visual must be the primary means of communicating the data. Other media can be part of a visualization, but the visualization must be able to stand on its own.

The result is readable and recognizable. There are many ways to transform data into images, most of which do not allow the viewer to understand the underlying data. A visualization must produce images that are readable by a viewer, even if that requires training and practice. Visualization images must also be recognizable as such, and not appear to be something else. The use of additional elements (or even “eye candy”) is certainly possible, but must not take precedence over the communication goals of the visualization.

Visualizations also have other properties like interaction, visual efficiency, etc. And while these are certainly important, the above criteria appear to be sufficient to precisely define information visualization the way it is generally used in its technical sense.

While the first two criteria are quite obvious, the last one is important for the rest of the discussion in this paper. Manovich [26] defines visualization as “situations when quantified data which by itself is not visual [...] is transformed into a visual representation.” Of course, any program that produces a visual output translates some kind of non-visual information into a visual representation. But Manovich’s definition requires the program to get data from outside, and not just produce it inside itself. Still, the criterion is only necessary, but not sufficient: a transformation of data into a visual shape does not imply readability. An example for a visual mappings from data for use as icons are VisualIDs [15]: unique visual forms that are based on data, but do not provide any information about it. One particular class of visualizations that are data-based but not readable are music visualizations like MilkDrop [23] (Figure 1c), but most artistic visualizations also fall into this group.

In addition to readability, a visualization has to be made with the intent to communicate data. This can be illustrated with an example of *informative art* [18]: a display that looks like a Mondrian painting to show a bus schedule (Figure 1b). The visualization is easily readable for those who know how, but not recognizable as one. Consequently, one of the authors of that work later developed a model of the comprehension of ambient displays [8], which consists of three steps: realizing *that* data is being visualized by the image, understanding *what* is being visualized, and *how* the display is to be read. Only when the user has reached that last level can s/he make use of the display.

It can therefore be argued that the utilitarian appearance of many visualizations actually serves a purpose, in helping the user take at least the first step. The question remains, though, if an aesthetically pleasing visualization has to appear like a work of art, or can be easily recognizable at the same time.

4 Artistic and Pragmatic Visualization

Kelly [10] defines aesthetics as “critical reflection on art, culture, and nature”. Critical thinking is the basis of all science, and also connects the technical approaches to pragmatic visualization with philosophy and artistic visualization. A particular type of critical thinking is an important part of the process in design and the arts: criticism (see Section 5). Aesthetic approaches are also being applied to computer science in an approach called *aesthetic computing* [6].

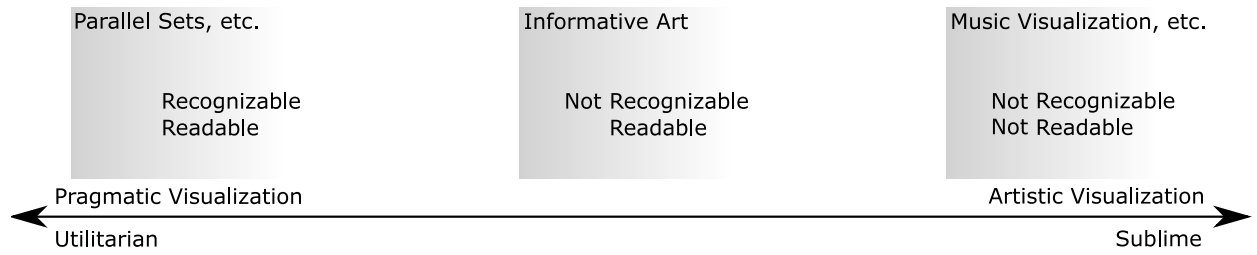
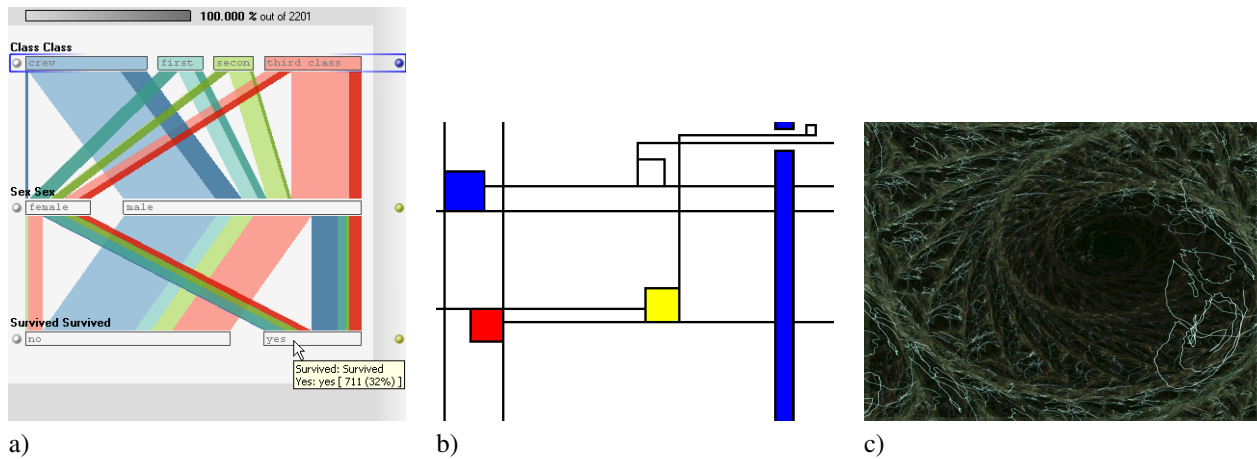


Figure 1. The gamut of data-based visualization. a) Parallel Sets [12] show data about the people on the Titanic, and are readable and recognizable as a visualization; b) Ambient visualization [18] visualizing a bus schedule are readable but require more effort and are not readily recognizable as a visualization; c) Music visualization like MilkDrop [23] is also based on data, but not readable.

4.1 The Sublime

One aesthetic criterion of particular interest is the sublime. The sublime can be understood as that which inspires awe, grandeur, and evokes a deep emotional and/or intellectual response. Works of art generally possess a sublime quality, making them enigmatic and captivating at the same time. Sack [16] equates its opposite, the anti-sublime, with *user friendliness*, which is a central concept in computer science. In fact, visualization is generally understood to be a part of human-centered computing [11], and techniques that are published at the main conferences and in journals usually need to be evaluated in user studies [13]. They are thus designed to remove any sublimity, and instead foster immediate understanding.

While the sublime is just one criterion in aesthetics, it is an incredibly useful one for this discussion. The data-based visualization examples discussed above and shown in Figure 1 can be easily classified using a measure of their sublimity: while the classical technical information visualization is entirely anti-sublime, artistic visualizations are primarily sublime.

The sublime subsumes the two criteria of readability and recognizability, since for a work of art to be sublime, it cannot be easily readable (or user friendly). It must present enough of an enigma to keep an audience interested without being easy to solve. The opposite is obviously true for a tool that is designed to aid in data analysis.

4.2 Pragmatic Visualization

Pragmatic visualization is what we term the technical application of visualization techniques to analyze data. The goal of pragmatic visualization is to explore, analyze, or present information in a way that allows the user to thoroughly understand the data. Card et al. describe this process as *knowledge crystallization* [3], and the recent initiatives in visual analytics [19] have used the slogan *Detecting the Expected, Discovering the UnexpectedTM*.

Visual efficiency is of course a key criterion for work in visualization. The goal is to produce images that convey the data as quickly and effortlessly as possible. User studies are conducted to measure the speed and accuracy of users, and to compare different methods and tasks [13].

While data is often hard to come by for pure academic research, the field is driven by the need to analyze and understand vast amounts of data, and the particular characteristics of different data sets are often the motivation to develop new methods.

Pragmatic visualization techniques are also often general, and can be applied to many different data sets. This is considered a strength, because the user can gain experience with the method and apply that to different data, rather than having to start from scratch again. There are of course examples for very specific visualization techniques (e.g., for real-time cardiovascular data in an intensive care unit [1]), but most of the work can be generalized to many different types of data.

4.3 Artistic Visualization

The goal of artistic visualization is usually to communicate a concern, rather than to show data. The data is used as the basis, the raw material. It also provides a proof that the concern in question is, in fact, real. This is perhaps why artists call this visualization: the underlying problem may not be visible, but is made visible through the piece.

Visual efficiency does not play a role in artistic visualization, quite the contrary. The goal is not to enable the user to read the data, but to understand the basic concern. In many ways, this step is the opposite of pragmatic visualization: rather than making the data easily readable, it is transformed into something that is visible and interesting, but that must still be readily understood. In other words, artistic visualization has a sublime quality that pragmatic visualization does not have.

Data collection is often an integral part of a visualization art piece. The fact that the data exists at all can be used to create awareness, and data flowing in in real time can make the piece “live”.

An example for this is the *Carnivore* project, which was named after the FBI program of the same name. The original Carnivore was a surveillance tool that made it possible to scan millions of emails each day, only extracting the “meat” of all that traffic: suspicious emails that would then be checked by hand. The artistic project of the same name [27] “sniffs” the traffic going through a network, and provides that data to different visualization modules. These usually show small and partially obscured snippets of the traffic, which the user recognizes as parts of web pages, emails, etc., thus realizing how much of the network traffic s/he produces can be read easily.

Other examples include blog visualizations such as *The Dumpster* [25] and *We Feel Fine* [24]. Both show information collected from the internet, and analyzed for certain words. The overall visualizations do not provide a lot of information, but the user can click on any of the animated

disks that represent postings, and read them.

4.4 Navigating the Space in Between

The fact that artistic and pragmatic visualizations are on opposite ends of the sublimity scale (Figure 1), and thus theoretically impossible to reconcile, should not deter us from trying, though. Interaction in particular is a way to enable the user to choose which side of a visualization s/he wants to see. *We Feel Fine* has a mode that allows the user to arrange the individual postings in ways that allow him or her to read the relative sizes of male vs. female authors, for example. Another example is *Artifacts of the Presence Era* [21], which uses a metaphor of sediment deposits to organize images taken as a memento from the former building of a museum. The presentation of the images is undoubtedly sublime, but the user can interact with the installation and look for patterns and specific images.

5 Visualization Criticism

Art theory is art criticism – in order to write about art, critics had to develop a vocabulary and a theoretical framework to put their work into. According to Britannica Online [22], “art criticism is often tied to theory; it is interpretive, involving the effort to understand a particular work of art from a theoretical perspective and to establish its significance in the history of art.”

Both theory and a language are largely missing in visualization. The main method of communicating new ideas is the research paper, which does not lend itself very well to showing anything but static images. Interactions therefore tend to be neglected in papers and consequently also in research work. Both images and interactions are usually described in what different parts look like, but not what those mean to the user. The use of criticism is a possible path towards developing parts of a theory and a language.

The first use of criticism in a visualization class (to our knowledge) was in 2002 by David Laidlaw and Fritz Drury in the course *Virtual Reality Design for Science* [9] at Brown University and the Rhode Island School of Design (RISD). A recent session on visualization education at the Visualization Conference 2006 showed that many visualization researchers use critiquing in their visualization classes now. What is more, some even report using the technique for other classes they teach that are much more technical, like software engineering. Why do the same researchers not use the methods they see work in their classrooms in their scientific work?

We therefore propose the use of criticism in visualization. Visualization criticism is an organized and well-defined channel to discuss work in visualization, and to receive academic credit for that (through publication). The

goal of criticism is as much to develop the basis for the criticism (language and theory) as pointing out problems with specific visualization approaches.

Appropriating Kelly's words, visualization criticism is critical thinking about visualization.

5.1 Process and Rules

In the art world, critics are very rarely artists, and artists usually do not work as critics. There are exceptions, but they are rare, and are usually considered conflicts of interest. In the world of visualization, critics cannot be separate from visualization researchers, and there are clearly advantages to that. The critical work will inform and guide one's creative and/or scientific work, and make one more aware of decisions. This in turn will lead to more reflection, and thus a more critical view overall and more theoretical work in a natural way.

At the same time, of course, this produces a problem: does a visualization researcher write critically about somebody else's work because of genuine interest, or simply to promote his or her own research?

We propose the following rules to guide the process of visualization criticism, and to facilitate work based on critiques.

Neutral voice. Criticism must be expressed in a way that states the facts and presents them in the most balanced possible light. Inflammatory remarks or *ad hominem* attacks are unacceptable. The goal of the critique is to discuss the work, not the researcher.

Facts. Every statement must be backed up by facts that can be independently checked. The perfect critique would include original research work that was done to collect evidence to back up claims (e.g., a user study on a particular aspect of a visualization). Mere opinions or anecdotal evidence are not enough, unless accompanied by more reliable evidence that points in the same direction.

No self-promotion. The critics' own work can only be cited as an example if there are also other examples, and cannot be used as the gold standard. Ideally, the critic will not use his or her own work as an example at all, in order to increase the credibility of the critique. Researchers are of course experts in their own work, and since one of the goals of a visualization critique is to lay the foundations for new creative work, a connection to the critic's own work will be unavoidable in many cases.

Clear goal. A critique must serve a goal. Simply criticizing a work for its shortcomings is not enough. The critic must state an alternative solution in a way that

is clear and complete enough to provide the basis for further research.

Despite all these rules, there is an expectation of a point of view, or *voice*, from which a visualization critique is written. Just as technical papers are written in response to an application need or to investigate a theoretical question, the motivation for a critique will be apparent from the text. As in art, there is not just one possible view on most things, and plenty of room for healthy debate.

Visualization criticism will only be feasible from a pragmatic point of view if it can be published, and thus provide academic credit. This is currently not the case, and theoretical papers in general are difficult to publish in the world of pragmatic visualization. There is no sharp distinction between accepted types of publications (like design and user studies) at some conferences and criticism, however, and so it is conceivable that the boundaries will be pushed out further over time, until purely critical work will be publishable. Visualization criticism can also work as an addition to the peer review process (which in itself is pure criticism), especially when applied to preliminary work or submissions by students.

Visualization criticism is geared towards information visualization, where more artistic approaches are generally more acceptable than in scientific visualization. There is no reason, however, why visualization criticism would not be possible (and useful) in scientific visualization as well.

5.2 From Criticism to Theory – to Application

The ultimate goal of visualization criticism is to provide building blocks for a theory of visualization. Criticism is where theory and practice meet, and each is used to develop, evaluate, and validate the other. Impulses for new ideas on both sides come from criticism, through the friction that is caused when bringing the two together.

There will be many other aspects of a theory of visualization, of course, coming from computer graphics, perceptual psychology, etc. But the specific questions that can be asked from an artistic or aesthetic point of view are largely ignored (and even unknown) so far. How do we attach meaning to graphical objects? How should we represent different kinds of data to make them easier to understand? What role do metaphors play, and how can they be used? Etc.

Theory does not just exist for its own sake, but enables the designers of visualizations for concrete purposes to draw not just from a huge pool of existing solutions, but from principles and guidelines that are applicable in a much broader way. This would be akin to an engineering field, where the basic laws of nature (e.g., physics) are used to build concrete and useful things (e.g., bridges).

Conclusions

Different kinds of visualization share some aspects, but there are also considerable differences. These differences are not a problem, but rather an opportunity. Only in understanding the differences between the different kinds of visual communication can we learn more about our respective work, and how we might build bridges to others.

Clear criteria are needed to get a meaningful overview over the currently rather amorphous mass of different visualization approaches that exist. Pointing out differences must not be understood as a way of rejecting collaboration, but as the first step towards a more informed and useful way of working together.

By digging deeper, we discover common ideas and approaches, such as critical thinking. Appropriating ideas common in the arts, but modeling them into a modus operandi acceptable for a scientific discipline, we can build new things that are much larger and richer than the sums of their parts.

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